

What we claim:

1. An integrated system for aircraft vortex safety, the system comprising:

a informational subsystem (1) of the aircraft parameters capable of receiving, saving and providing the user with information on the aircraft configuration, position, flight velocity, and attitude;

a informational subsystem (2) of vortex generators capable of receiving, saving and providing the user with information on vortex generator configuration, position, flight velocity, and attitude for all vortex generators located in the aircraft vicinity;

a informational subsystem (3) of ambient parameters capable of receiving, saving and providing the user with information on ambient conditions in the aircraft vicinity at the forecasted time;

a subsystem (4) warning the users against a risk of the aircraft encounter with vortex generator wake vortices at the forecasted time;

a user subsystem (5) capable of receiving, saving and providing the users with information from other subsystems and forming the instructive signal for the aircraft evasion maneuver ensuring the aircraft evasion from the vortex generator danger areas during the chosen by the user delay time after the user receives the warning signal about a risk of the aircraft encounter with vortex generator wake vortices at the forecasted time;

a communication subsystem (6) ensuring integration of the subsystems into the united complex.

2. The system as claimed in claim 1 wherein:

said informational subsystem (1) of the aircraft parameters ensures receipt, processing, saving, and transmitting information to the warning subsystem at least on the aircraft configuration, coordinates and attitude in the inertial frame, on the aircraft velocity and angular rate components in the aircraft frame;

said informational subsystem (2) of vortex generators ensures receipt, processing, saving, and transmitting information to the user at least on the vortex generator types, coordinates and attitude, velocity and angular rate components in the inertial frame;

said informational subsystem (3) of ambient parameters ensures receipt, processing, saving, and transmitting information to the user at least on the wind velocity components in the inertial frame at different altitudes in the region of the wake vortex presence, as well as on the ambient turbulence;

said warning subsystem (4) informing the user on a possibility of the aircraft encountering with the vortex generator danger areas performs at least calculation of the vortex generator wake vortex danger area position and intensity, the area of the aircraft forecasted positions at the forecasted time and directs to the user subsystem information on a possibility of the aircraft encountering with the vortex generator wake vortex danger areas at the forecasted time;

said user subsystem (5) receives, processes, saves and indicates the information from the warning subsystem at least on the nulling the distance from the area of the aircraft forecasted positions to the vortex generator wake vortex danger area at the forecasted time and forms a signal indicating the change of the aircraft position providing the increase of the above mentioned distance.

3. The system as claimed in claim 1 or 2 wherein:

said aircraft informational subsystem (1) is realized on the basis of the aircraft standard onboard equipment and/or equipment of ground-based, seaborne and/or aerospace navigation complexes;

said vortex generator informational subsystem (2) is realized on the basis of the aircraft standard onboard equipment and/or the vortex generator standard equipment, and/or equipment of the air traffic control for ground, sea, or aerospace complexes;

said environmental information subsystem (3) is realized on the basis of the aircraft standard onboard equipment and/or of standard meteorological equipment for the air traffic control system or of equipment in the ground-based, sea and/or aerospace navigation complexes;

said warning subsystem (4) informing the user on the possibility of the aircraft encountering with the vortex generator wake vortex danger areas is realized on the basis of the user computer software and/or onboard unified indication systems and/or indication systems of air traffic control services or ground-based equipment in seaborne and/or aerospace navigation complexes at the site of the flight controller;

said user subsystem (5) is realized on the basis of the user computer and navigational systems belonging to the aircraft onboard standard equipment and/or ground-based or seaborne navigation complexes at the site of the flight controller;

said commutation subsystem (6) is realized on the basis of data-transmission communication systems and/or onboard multiplex channels of informational exchange.

4. The system as claimed in any of claims 1-3 wherein the user is the aircraft and the instructive signal is realized in the aircraft flight control system.

5. The system as claimed in any of claims 1-3 wherein the user is the air traffic control services and the instructive signal is realized in the aircraft flight control system.

6. The system as claimed in any of claims 1-5 wherein said warning subsystem (4) informing the user on the possibility of the aircraft encountering with the vortex generator wake vortex danger areas at the forecasted time includes a system comprising:

a aircraft tracker (7) capable of receiving information on the aircraft configuration, position, coordinates, and attitude in the inertial frame at the current time;

a vortex generator tracker (8) capable of receiving information on the vortex generator position, geometrical and weight characteristics, as well as on the motion parameters in the inertial frame at the current time;

a memory unit (9) capable of saving information on the vortex generator position and motion parameters in the inertial frame;

a ambient parameter detector (10) capable of receiving information on the environmental parameters in the space of the collocation of the aircraft and vortex generator at the current time;

a wake vortex tracker (11) capable of determining the vortex generator wake vortices in the form of the set of the vorticity center paths in the inertial frame;

a memory device (12) capable of storing information on the vortex generator wake vortex path point coordinates in the form of the set of the vorticity region centers and wake vortex intensity in the inertial frame;

a device (13) for selection of the delay time capable of calculating the time period within which the aircraft has at least a possibility of a flight evasive maneuver providing evasion of the aircraft from the generator wake danger area after the signal warning against the possibility of wake encounter has been received;

a device (14) for simulation of the control plane capable of calculating the delay distance, which equals to the distance covered by the aircraft during the delay time, modeling the control plane situated in front of the aircraft perpendicular to its flight direction at the delay distance, and determining the forecasted time necessary for the aircraft to gain the control plane in the inertial frame;

a device (15) for determination of the danger area parameters capable of determining the geometrical characteristics of the generator wake vortex danger areas in the form of the set of the danger areas of the generator vorticity regions at the forecasted time;

a forecasting device (16) capable of determining the generator wake path in the form of the set of the generator vorticity region centers with respect to the inertial frame and of the intensity of the generator wake vortices at the forecasted time;

a device (17) for calculation of the intersection points capable of determining the coordinates of the intersection points of the generator wake vortex trajectory and the control plane at the forecasted time of the aircraft flight through it;

a areas and regions forming device (18) capable of forming around the intersection point of the wake vortex path and the control plane of the wake vortex danger area in the form of the set of the generator vorticity danger areas, where the entering aircraft may have the flight parameters exceeding the admissible limits; forming in the control plane of the area of the aircraft forecasted positions at the forecasted time of the aircraft intersection with the control plane with due regard to the flight regulations; forming around the region of the aircraft forecasted positions of the alert area; the information on the entrance of the wake danger areas into the warning area will be provided to the user;

a transformation unit (19) capable of calculating the coordinates of the area of the aircraft forecasted positions, of the warning area and of the wake vortex danger area in the aircraft frame;

first intersection conditional test unit (20) capable of calculating the distance from the alert area to the wake vortex danger area and marking its nulling;

second intersection conditional test unit (21) capable of calculating the distance from the area of the aircraft forecasted positions to the wake vortex danger area and marking its nulling;

first indication unit (22) capable of forming and transmitting the nulling signal for the distance from the area of the aircraft forecasted positions to the vortex generator wake vortex danger area;

second indication unit (23) capable of indicating the nulling of the distance from the warning area to the to the vortex generator wake vortex danger area.

7. The system as claimed in claim 6 wherein:

said aircraft parameters tracker (7) is capable of receiving information at least on the aircraft configuration, coordinates, flight velocity, pitch, yaw and roll angles;

said vortex generator tracker (8) is capable of receiving information at least on the vortex generator type, flight velocity, angular rates, and coordinates of the generator path points;

said ambient parameters detector (10) is capable of receiving information at least on the magnitude and direction of the local wind velocity, the altitude wind profile, ambient turbulence intensity, and the underlying terrain type;

said wake vortex tracker (11) is capable of determining the vortex generator wake vortex path in the form of the set of the generator vorticity area centers and the wake vortex intensity on the basis of the saved information on the vortex generator type, velocity, angular rates, and coordinates of the generator path points;

said device (14) for simulation of the control plane is capable of modeling the control plane on the basis of the information on the aircraft position, attitude, velocity, and the delay time;

said device (15) for determination of the danger area parameters is capable of determining the geometrical characteristics of the generator wake vortex danger areas on the basis of the saved information on the trajectory point coordinates and intensity of the generator wake vortices, as well as of the information on the aircraft configuration, position, velocity and angular rates in the inertial frame;

said forecasting device (16) is capable of determining the vortex generator wake vortex path and intensity on the basis of the information on the wake path in the form of the set of the trajectories of the generator vorticity region centers in the inertial frame and of the wake intensity;

said device (17) for calculation of the intersection points is capable of determining the coordinates of the intersection points of the generator wake vortex trajectory and the control plane on the basis of the information on the coordinates of the control plane and the wake vortex trajectory in the inertial frame at the forecasted time;

said areas and regions forming device (18) is capable of forming the wake vortex danger area, area of the aircraft forecasted positions and the alert area on the basis of the information on the coordinates of the intersection point of the generator wake vortex path and the control plane at the forecasted time, of the information on the geometrical characteristics of the danger area in the form of the set of the generator vorticity danger areas, of the information on the aircraft position, attitude, velocity and angular rates with due regard for the flight regulations in the inertial frame;

said transformation unit (19) is capable of calculating the coordinates of the area of the aircraft forecasted positions, of the alert area, and of the wake vortex danger area in the aircraft frame on the basis of information on the coordinates of the area of the aircraft forecasted positions, of the alert area, and of the wake vortex danger area, as well as of information on the aircraft coordinates and attitude, preferably on the pitch, yaw and roll angles in the inertial frame at the current time.

8. The system as claimed in any of claims 6 or 7 wherein said warning subsystem (4) comprises the vortex generator tracker (8), memory units (9 and 12), wake vortex tracker (11), device (15) for determination of the danger area parameters, forecasting device (16), device (17) for calculation of the intersection points, areas and regions forming device (18), first and the second units (19 and 20) testing the intersection conditions, signal devices capable of simultaneous functioning with respect of each of vortex generators located in the vicinity of the aircraft.

9. The system as claimed in any of claims 6–8 wherein said device (14) for selection of the delay time in the warning subsystem (4) is realized with the possibility of the current correction of the delay time.

10. The system as claimed in any of claims 6–9 wherein said areas and regions forming device (18) in said warning subsystem (4) is realized with the possibility of the current correction of the coordinates of the area of the aircraft forecasted positions.

11. The system as claimed in any of claims 6–10 wherein said areas and regions forming device (18) in said warning subsystem (4) is realized with the possibility of the current correction of the coordinates of the alert area.

12. The system as claimed in any of claims 9–11 wherein the correction is carried out in the manual mode.

13. The system as claimed in any of claims 9–11 wherein the correction is carried out in the semiautomatic or in automatic mode.

14. The system as claimed in any of claims 6–13 wherein said user subsystem (5) comprises a device (24) for visualization for the user of information on the location of the area of the aircraft forecasted positions and the vortex generator wake danger areas in the control surface.

15. The system as claimed in any of claims 6–14 wherein said user subsystem (5) comprises a indication device (22) and a alarm indication device (23) chosen from the group including visual, audio and tactile indication devices.

16. The system as claimed in any of claims 6–15 wherein said device (15) for determination of the vortex generator danger area parameters in said warning subsystem (4) contains:

- a unit (25) for the aircraft schematization capable of calculating the set of the aircraft geometrical characteristics necessary for evaluation of additional aerodynamic forces and moments induced by the generator wake vortices and acting on the aircraft on the basis of information on the aircraft configuration, coordinates, flight velocity, angles of pitch, yaw and roll;

- a unit (26) for evaluation of additional aerodynamic forces and moments acting on the aircraft at the given point and induced by the generator wake vortices, capable of calculating them on the basis of the saved information on the paths of the wake vortex points in the form of the sets of the trajectories of the vorticity area centers and the intensity of the generator wake vortices in the inertial frame, of the information on the aircraft configuration, position, flight velocity, angular rate in the inertial frame, and on the aircraft geometry;

- a unit (27) for estimation of the hazard level of the aerodynamic perturbations at the given point capable of estimating the hazard level on the basis of criteria chosen by the user;

- a unit (28) for determination of the points where the aircraft aerodynamic forces and moments induced by the generator wake vortices are dangerous capable of determining the coordinates of the points of the danger areas on the basis of their selection under the hazard criteria chosen by the user;

- a unit (29) for evaluation of the geometrical characteristics of the wake vortex danger areas capable of calculating them on the basis of information on the coordinates of points of the danger areas.

17. The system as claimed in claim 16 wherein said unit (29) for determination of the wake vortex danger area geometrical characteristics in said warning subsystem (4) in said unit (15) for determination of the danger area parameters is capable of approximating the danger area boundary.

18. The system as claimed in any of claims 1-17 wherein the aircraft admissible roll is chosen as the hazard criterion for the vortex generator wake vortices.

19. The system as claimed in any of claims 1-17 wherein the aircraft rolling moment induced by the vortex generator wake vortices is chosen as the hazard criterion for the vortex generator wake vortices.

20. The system as claimed in any of claims 6-19 wherein said wake vortex tracker (11) and said forecasting device (16) in said warning subsystem (4) comprise a programmable component, and said device (15) for determination of the danger area parameters is realized in the programmable component software.

21. The system as claimed in any of claims 6-20 wherein the devices and units of said warning subsystem (4) and said user subsystem (5) have the different localization.

22. The system as claimed in any of claims 1-21 wherein said user subsystem (5) comprises a system for storage of information on the delay time, coordinates of the control surface, area of the aircraft forecasted positions and the vortex generator danger areas at least within the time of alarm indication of the nulling event for the distance from the area of the aircraft forecasted positions to the danger area of the vortex generator wake vortices.